LISTING OF THE CLAIMS

This listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims

1. (Previously Presented) A coherent optical detection system receiving an incoming optical signal in an optical communications network, said system comprising:

a local oscillator emitting light;

a phase diverse hybrid for generating two replicas of the incoming signal and two replicas of the local oscillator light, said phase diverse hybrid combining the first replica of the incoming optical signal and the first replica of the local oscillator light into a first output and combining the second replica of the incoming optical signal and the second replica of the local oscillator light into a second output and wherein said local oscillator does not have to be phase locked to the incoming optical signal;

wherein the phase relationship between the optical signal and the local oscillator light in the first output is different from 0 degrees and different from 180 degrees compared to the phase relationship between the local oscillator light and the optical signal in the second output and the state of polarization of the optical signal relative to the local oscillator light in the first output is not orthogonal to the state of polarization of the optical signal relative to the local oscillator light in the second output; and

two photodetectors communicating with the phase diverse hybrid, wherein said two photodetectors receive optical signals from the two outputs and convert them to electrical signals;

whereby the electrical signals are processed to provide a complex representation of the envelope of the electric field of the incoming optical signal or a component of the complex representation of the envelope of the electric field of the incoming optical signal.

2. (Original) The coherent optical detection system of claim 1 wherein:

the electrical signals received by the two photodetectors are digitized by two A/D converters; and

a digital signal processor performs a computation on digital values from the A/D converters to provide a complex representation or component thereof of the incoming optical signal.

3. (Withdrawn) The coherent optical detection system of claim 1 wherein:

the electrical signals from the two photodetectors are separately multiplied by two electrical waveforms, each waveform being periodic and having the same frequency as the difference frequency between the local oscillator light and the incoming optical signal;

the waveforms having different phases from one another; and

the electrical signals corresponding to the results of two multiplication operations are summed to give an estimate of a component of the complex representation of the incoming optical signal.

4. (Original) The coherent optical detection system of claim 2 wherein the digital signal processor produces an output which is the result of a signal processing operation on a plurality of samples over time of the complex envelope of the electric field of the incoming optical signal.

5. (Withdrawn) The coherent optical detection system of claim 4 wherein the digital signal processor compensates for the chromatic dispersion experienced by the incoming optical signal.

6. (Withdrawn) A coherent optical detection system receiving an incoming optical signal in a fiber optics network, said system comprising:

a local oscillator emitting light;

an optical mixing hybrid for generating at least four replicas of the incoming optical signal and four replicas of the local oscillator light, said optical mixing hybrid combining the replicas of the incoming optical signal and the replicas of the local oscillator light into at least four outputs and wherein said local oscillator does not have to be phase locked to the incoming optical signal;

wherein four outputs of the at least four outputs of the optical mixing hybrid can be selected such that the Jones vector of the optical signal relative to the local oscillator light at each of the four selected outputs is distinct from the Jones vector of the optical signal relative to the local oscillator light at the other three of the selected outputs;

four photodetectors communicating with the optical mixing hybrid, wherein said four photodetectors receive optical signals from the four outputs;

four A/D converters to receive electrical signals from the four photodetectors, said four A/D converters digitizing the received electrical signals; and

a digital signal processor for performing computations on digital values from the four A/D converters to obtain information carried by the incoming optical signal without limitation to the state of polarization of the incoming optical signal.

7. (Withdrawn) The coherent optical detection system of claim 6 wherein:

the state of polarization of the optical signal relative the local oscillator light at the first and second of the selected outputs is not orthogonal, and the state of polarization of the optical signal relative the local oscillator light at the third and fourth of the selected outputs is not orthogonal, and the state of polarization at the first and second outputs is close to orthogonal to the state of polarization at the third and fourth outputs; and

the phase relationship between the optical signal and the local oscillator light at the first output is approximately 90 degrees compared to the phase relationship between the optical signal and the local oscillator light at the second output, and the phase relationship between the optical signal and the local oscillator light at the third output is approximately 90 degrees compared to the phase relationship between the optical signal and the local oscillator light at the fourth output.

8. (Withdrawn) The coherent optical detection system of claim 6 wherein the digital signal processor obtains a Jones vector representation or equivalent representation that includes the amplitude, phase and polarization of the incoming optical signal.

9. (Withdrawn) The coherent optical detection system of claim 8 wherein:

the incoming optical signal includes two optical channels being combined so that the first optical channel of the two optical channels has a state of polarization close to orthogonal to the second optical channel of the two optical channels; and

the digital signal processor performs computations to obtain information carried by each of the two polarization multiplexed channels in the incoming optical signal independent of the other channel.

10. (Withdrawn) The coherent optical detection system of claim 6 wherein the digital signal processor produces an output which is the result of a signal processing operation on a plurality of samples over time of the Jones vector of the incoming optical signal.

11. (Withdrawn) The coherent optical detection system of claim 10 wherein the digital signal processor compensates for the chromatic dispersion experienced by the incoming optical signal.

12. (Withdrawn) A coherent optical detection system receiving an incoming optical signal in an optical communications network, said system comprising:

two local oscillators, each local oscillator emitting light;

an optical mixing hybrid for generating at least four replicas of the incoming optical signal and two replicas of light from each of the local oscillators, said optical mixing hybrid combining the incoming optical signal and the local oscillator light into at

least four outputs and wherein said local oscillators do not have to be phase locked to the incoming optical signal;

a first output of the four outputs having a first replica of the optical signal and a first replica of light from the first local oscillator of the two local oscillators, wherein the state of polarization of the optical signal and the light emitted from the first local oscillator have a defined relationship;

a second output of the four outputs having a second replica of the optical signal and a second replica of light from the first local oscillator of the two local oscillators, wherein the phase relationship between the optical signal and the local oscillator light in the first output is different from 0 degrees and different from 180 degrees compared to the phase relationship between the local oscillator light and the optical signal in the second output;

a third output of the four outputs having a third replica of the optical signal and a first replica of light from the second local oscillator of the two local oscillators, wherein the state of polarization of the light from the second local oscillator with respect to the optical signal in the third output is close to orthogonal compared to the state of polarization of light from the first local oscillator with respect to the optical signal in the first output;

a fourth output of the four outputs having a fourth replica of the optical signal and a second replica of light from the second local oscillator of the two local oscillators, wherein the phase relationship between the optical signal and the local oscillator light in the third output is different from 0 degrees and different from 180 degrees compared to

the phase relationship between the local oscillator light and the optical signal in the fourth output;

at least four photodetectors communicating with the optical mixing hybrid, wherein said four photodetectors receive optical signals from the four outputs;

at least four A/D converters to receive electrical signals from the four photodetectors, said four A/D converters digitizing the electrical signals; and

a digital signal processor for performing computations on digital values from the four A/D converters to obtain information carried by the incoming optical signal.

13. (Withdrawn) A coherent optical detection system receiving an incoming optical signal containing information in a fiber optics network, said system comprising:

a local oscillator emitting light;

an optical mixing hybrid for combining the incoming optical signal and the local oscillator light into at least one output;

a photodetector communicating with the optical mixing hybrid, wherein said photodetector receives an optical signal from the output and converts it to an electrical signal;

an A/D converter to receive the electrical signal from said photodetector, said A/D converter digitizing the electrical signal; and

a digital signal processor for performing computations on digital values from the A/D converter, the digital signal processor producing an output which is the result of a signal processing operation on a plurality of samples over time of the complex envelope

of the electric field of the incoming optical signal, the output having the information contained in the incoming optical signal.

14. (Withdrawn) The coherent optical detection system of claim 13 wherein the digital signal processor at least partially reverses the effect of propagation of the incoming optical signal through an optical fiber transmission system.

15. (Withdrawn) The coherent optical detection system of claim 14 wherein the digital signal processor compensates for the chromatic dispersion of the optical fiber transmission system.

16. (Withdrawn) The coherent optical detection system of claim 15 wherein the signal processing operation performed by the digital signal processor compensates for the chromatic dispersion experienced by the optical signal by applying to the complex envelope of the incoming optical signal a convolution with a specified mathematical function, the mathematical function being close to the impulse response of the transfer function corresponding to a chromatic dispersion equal in magnitude and opposite to the chromatic dispersion of the optical fiber transmission system.

17. (Withdrawn) The coherent optical detection system of claim 14 wherein the signal processing operation performed by the digital signal processor at least partially reverses the effect of self phase modulation imposed on the incoming optical signal.

18. (Withdrawn) The coherent optical detection system of claim 13 wherein the signal processing operation performed by the digital signal processor at least partially reverses the effect of multipath interference imposed on the incoming optical signal.

19. (Withdrawn) The coherent optical detection system of claim 13 wherein the signal processing operation performed by the digital signal processor includes performing an optical filtering function on the complex envelope of the electric field.

20. (Withdrawn) The coherent optical detection system of claim 13 wherein the signal processing operation performed by the digital signal processor improves the quality of the incoming optical signal, the digital signal processor applying an algorithm which utilizes parameters that are adjusted to give different signal processing functions, and the values of those parameters are chosen for improving the quality of the recovered signal.

21. (Withdrawn) The coherent optical detection system of claim 20 wherein the signal processing operation that improves the quality of the recovered signal is a feedforward equalization-decision feedback equalization function.

22. (Withdrawn) The coherent detection system of claim 20 wherein the signal processing operation that improves the quality of the recovered signal is a maximum likelihood sequence estimation function.

23. (Withdrawn) The coherent optical detection system of claim 13 wherein the digital signal processor produces an output which is the result of a signal processing operation on a plurality of samples over time of the Jones vector of the incoming optical signal.

24. (Withdrawn) The coherent optical detection system of claim 23 wherein the digital signal processor compensates for the chromatic dispersion experienced by the incoming optical signal.

25. (Withdrawn) The coherent optical detection system of claim 23 wherein the signal processing operation performed by the digital signal processor at least partially reverses the effect of polarization mode dispersion imposed on the incoming optical signal.

26. (Withdrawn) A coherent optical detection system receiving an incoming optical signal having a plurality of wave division multiplexed (WDM) channels, said system comprising:

at least one local oscillator emitting light;

an optical mixing hybrid for combining the incoming optical signal and the local oscillator light into at least one output;

a photodetector communicating with the optical mixing hybrid, wherein said photodetector receives optical signals from the output;

an A/D converter to receive electrical signals from said photodetector, said A/D converter digitizing the electrical signals; and

a digital signal processor for performing computations on digital values from the A/D converter, the digital signal processor estimating information carried on a first of the plurality of WDM channels that takes into account the other WDM channels and subtracts crosstalk imposed on the first WDM channel by at least one of the remainder of the plurality of WDM channels.

27. (Withdrawn) The coherent optical detection system of claim 26 wherein the crosstalk arises because the optical spectrum of the first WDM channels is partially overlapped over the optical spectrum of a second WDM channel of the incoming optical signal

28. (Withdrawn) The coherent optical detection system of claim 26 wherein the crosstalk is cross phase modulation imposed on the first WDM channel by a second WDM channel during passage through an optical fiber transmission system.

29. (Withdrawn) The coherent optical detection system of claim 26 wherein the crosstalk is caused by four wave mixing occurring when the plurality of WDM

channels generates a four wave mixing product which at least partially overlaps the optical spectrum of the WDM channel that experiences the crosstalk.

30. (Previously Presented) A method of receiving an incoming optical signal in a coherent optical detection system, said method comprising the steps of:

emitting light from a local oscillator, said local oscillator not requiring a phase lock with the incoming optical signal;

generating two replicas of the incoming signal and two replicas of the local oscillator light by a phase diverse hybrid;

combining, by the phase diverse hybrid, the first replica of the incoming optical signal and the first replica of the local oscillator light into a first output;

combining the second replica of the incoming optical signal and the second replica of the local oscillator light into a second output, wherein the phase relationship between the optical signal and the local oscillator light in the first output is different from 0 degrees and different from 180 degrees compared to the phase relationship between the local oscillator light and the optical signal in the second output and the state of polarization of the optical signal relative to the local oscillator light in the first output is not orthogonal to the state of polarization of the optical signal relative to the local oscillator light in the second output;

receiving optical signals from the two outputs by two photodetectors in communication with the phase diverse hybrid; and

converting the optical signals from the two outputs into electrical signals, the electrical signals being processed to provide a complex representation of the envelope

of the electric field of the incoming optical signal or a component of the complex representation of the envelope of the electric field of the incoming optical signal.

31. (Original) The method of receiving an incoming optical signal of claim 30 wherein the step of converting the optical signals includes:

digitizing the electrical signals by two A/D converters; and

performing a computation on digital values from the A/D converters by a digital signal processor to provide a complex representation or component thereof of the incoming optical signal.

32. (Withdrawn) The method of receiving an incoming optical signal of claim 30 wherein the step of converting the optical signals includes the steps of:

multiplying the electric signals separately by two electrical waveforms, each waveform being periodic and having the same frequency as the difference frequency between the local oscillator light and the incoming optical signal and wherein the two electrical waveforms have different phases from one another; and

summing the electrical signals corresponding to the results of the two multiplication operations to give an estimate of a component of the complex representation of the incoming optical signal.

33. (Withdrawn) A method of receiving an incoming optical signal in a coherent optical detection system, said method comprising the steps of:

emitting light from a local oscillator, said local oscillator not requiring a phase lock with the incoming optical signal;

generating at least four replicas of the incoming optical signal and four replicas of the local oscillator light by an optical mixing hybrid;

combining, by the optical mixing hybrid, the replicas of the incoming optical signal and the replicas of the local oscillator light into at least four outputs, wherein four outputs of the at least four outputs of the optical mixing hybrid can be selected such that the Jones vector of the optical signal relative to the local oscillator light at each of the four selected outputs is distinct from the Jones vector of the optical signal relative to the local oscillator light at the other three of the selected outputs;

receiving optical signals from the four outputs by four photodetectors in communication with the optical mixing hybrid;

digitizing electrical signals, by four A/D converters, from the four photodetectors; and

performing computations, by a digital signal processor, on digital values from the four A/D converters to obtain information carried by the incoming optical signal without limitation to the state of polarization of the incoming optical signal.

34. (Withdrawn) The method of receiving an incoming optical signal of claim 33 wherein:

the state of polarization of the optical signal relative the local oscillator light at the first and second of the selected outputs is not orthogonal, and the state of polarization of the optical signal relative the local oscillator light at the third and fourth of the selected

outputs is not orthogonal, and the state of polarization at the first and second outputs is close to orthogonal to the state of polarization at the third and fourth outputs; and

the phase relationship between the optical signal and the local oscillator light at the first output is approximately 90 degrees compared to the phase relationship between the optical signal and the local oscillator light at the second output, and the phase relationship between the optical signal and the local oscillator light at the third output is approximately 90 degrees compared to the phase relationship between the optical signal and the local oscillator light at the fourth output.

35. (Withdrawn) The method of receiving an incoming optical signal of claim 33 wherein the step of performing computations by the digital signal processor includes obtaining a Jones vector representation or equivalent representation that includes the amplitude, phase and polarization of the incoming optical signal.

36. (Withdrawn) The method of receiving an incoming optical signal of claim 33 wherein the step of performing computations by the digital signal processor includes producing an output which is the result of a signal processing operation on a plurality of samples over time of the Jones vector of the incoming optical signal.

37. (Withdrawn) A method of receiving an incoming optical signal in a coherent optical detection system, said method comprising the steps of:

emitting light from first and second local oscillators, each local oscillator not requiring a phase lock with the incoming optical signal;

generating four replicas of the incoming signal and two replicas from each of the local oscillators light by an optical mixing hybrid;

combining, by the optical mixing hybrid into at least four outputs;

wherein a first output of the four outputs has a first replica of the optical signal and a first replica of light from the first local oscillator and the state of polarization of the incoming optical signal and the light emitted from the first local oscillator in the first input has a defined relationship;

wherein a second output of the four outputs includes a second replica of the optical signal and a first replica of light from the second local oscillator and the state of polarization of the light from the second local oscillator with respect to the optical signal in the second input is close to orthogonal compared to the state of polarization of the light from the first local oscillator with respect to the optical signal in the first output;

receiving optical signals from the two outputs by at least two photodetectors in communication with the optical mixing hybrid;

digitizing electrical signals, by at least two A/D converters, from the at least two photodetectors; and

performing computations, by a digital signal processor, on digital values from the at least two A/D converters to obtain information carried by the incoming optical signal.

38. (Withdrawn) A method of receiving an incoming optical signal containing information in a coherent optical detection system, said method comprising the steps of:

emitting light from a local oscillator;

combining, by an optical mixing hybrid, the incoming optical signal and the local oscillator light into at least one output;

receiving optical signals from the output by a photodetector in communication with the optical mixing hybrid; and

converting the optical signal into an electrical signal by the photodetector;

digitizing the electrical signal by an A/D converter; and

performing computations, by a digital signal processor, on digital values from the A/D converter, the digital signal processor producing an output which is the result of a signal processing operation on a plurality of samples over time of the complex envelope of the electric field of the incoming optical signal, wherein the output has the information contained in the incoming optical signal.

39. (Withdrawn) The method of receiving an incoming optical signal of claim 38 wherein the step of performing computations by a digital signal processor includes reversing at least partially the effect of propagation of the signal through an optical fiber transmission system.

40. (Withdrawn) The method of receiving an incoming optical signal of claim 38 wherein the step of performing computations by a digital signal processor includes reversing at least partially the effect of multipath interference imposed on the incoming optical signal.

41. (Withdrawn) The method of receiving an incoming optical signal of claim 38 wherein the step of performing computations by a digital signal processor includes performing an optical filtering function on the complex envelope of the electric field.

42. (Withdrawn) A method of receiving an incoming optical signal in a coherent optical detection system, said incoming optical signal having a plurality of WDM channels, said method comprising the steps of:

emitting light from at least one local oscillator;

combining, by an optical mixing hybrid, the incoming optical signal and the local oscillator light into at least one output;

receiving optical signals from the output by a photodetector in communication with the optical mixing hybrid;

converting the optical signal into an electrical signal by the photodetector;

digitizing the electrical signal from the photodetector by an A/D converters; and

performing computations, by a digital signal processor, on digital values from the A/D converter, the digital signal processor estimating information carried on a first of the plurality of WDM channels that takes into account the other WDM channels and subtracts crosstalk imposed on the first WDM channel by at least one of the remainder of the plurality of WDM channels.

43. (Withdrawn) The method of receiving an incoming optical signal of claim 42 wherein the crosstalk is cross phase modulation imposed on the first WDM channel by a second WDM channel during passage through an optical fiber transmission system.

44. (Withdrawn) The method of receiving an incoming optical signal of claim 42 wherein the crosstalk is caused by four wave mixing occurring when the plurality of WDM channels generates a four wave mixing product which at least partially overlaps the optical spectrum of the WDM channel that experiences the crosstalk.

45. (Withdrawn) A heterodyne coherent optical detection system receiving an incoming optical signal in a fiber optics network, said system comprising:

a local oscillator emitting light;

a polarization diversity hybrid for generating two replicas of the incoming optical signal and two replicas of the light from the local oscillator, said polarization diversity hybrid combining the incoming optical signal and the local oscillator light into at least two outputs, wherein the state of polarization of the incoming optical signal relative to the light from the local oscillator at the first output is close to orthogonal to the state of polarization of the incoming optical signal relative to the light from the local oscillator at the second output;

wherein the incoming optical signal includes two optical channels being combined so that the first optical channel of the two optical channels has a state of polarization close to orthogonal to the second optical channel of the two optical channels;

two photodetectors communicating with the optical mixing hybrid, wherein said photodetectors receive optical signals from the outputs and convert them to electrical signals;

two A/D converters to receive the electrical signals from said photodetectors, said A/D converters digitizing the electrical signals; and

a digital signal processor for performing computations on digital values from the A/D converters to obtain information carried by each of the two polarization multiplexed channels in the incoming optical signal independent of the other channel.

46. (Canceled)

47. (New) The coherent optical detection system of claim 4 wherein the digital signal processor at least partially reverses the effect of propagation of the incoming optical signal through an optical fiber transmission system.

48. (New) The coherent optical detection system of claim 47 wherein the digital signal processor compensates for the chromatic dispersion of the optical fiber transmission system.

49. (New) The coherent optical detection system of claim 48 wherein the signal processing operation performed by the digital signal processor compensates for the chromatic dispersion experienced by the optical signal by applying to the complex envelope of the incoming optical signal a convolution with a specified mathematical function, the mathematical function being close to the impulse response of the transfer function corresponding to a chromatic dispersion equal in magnitude and opposite to the chromatic dispersion of the optical fiber transmission system.

50. (New) The coherent optical detection system of claim 47 wherein the signal processing operation performed by the digital signal processor at least partially reverses the effect of self phase modulation imposed on the incoming optical signal.

51. (New) The coherent optical detection system of original claim 4 wherein the signal processing operation performed by the digital signal processor at least partially reverses the effect of multipath interference imposed on the incoming optical signal.

52. (New) The coherent optical detection system of claim 4 wherein the signal processing operation performed by the digital signal processor includes performing an optical filtering function on the complex envelope of the electric field.

53. (New) The coherent optical detection system of claim 4 wherein the signal processing operation performed by the digital signal processor improves the quality of the incoming optical signal, the digital signal processor applying an algorithm which utilizes parameters that are adjusted to give different signal processing functions, and the values of those parameters are chosen for improving the quality of the recovered signal.

54. (New) The coherent optical detection system of claim 53 wherein the signal processing operation that improves the quality of the recovered signal is a feedforward equalization-decision feedback equalization function.

55. (New) The coherent detection system of claim 53 wherein the signal processing operation that improves the quality of the recovered signal is a maximum likelihood sequence estimation function.

56. (New) The method of receiving an incoming optical signal of claim 31 further comprising the step of producing an output from the digital signal processor which is the result of a signal processing operation on a plurality of samples over time of

the complex envelope of the electric field of the incoming optical signal, wherein the output has the information contained in the incoming optical signal.

57. (New) The method of receiving an incoming optical signal of claim 56 wherein the step of performing computations by a digital signal processor includes reversing at least partially the effect of propagation of the signal through an optical fiber transmission system.

58. (New) The method of receiving an incoming optical signal of claim 57 wherein the step of performing computations by a digital signal processor includes reversing at least partially the effect of the chromatic dispersion of the optical fiber transmission system on the optical signal.

59. (New) The method of receiving an incoming optical signal of claim 56 wherein the step of performing computations by a digital signal processor includes reversing at least partially the effect of multipath interference imposed on the incoming optical signal.

60. (New) The method of receiving an incoming optical signal of claim 56 wherein the step of performing computations by a digital signal processor includes performing an optical filtering function on the complex envelope of the electric field.

61. (New) The method of receiving an incoming optical signal of claim 31 wherein the incoming optical signal contains a plurality of WDM channels, further comprising the steps of:

compensating for crosstalk imposed on a first of the plurality of WDM channels by at least one of the remainder of the plurality of WDM channels; and

estimating the information carried on the first of the plurality of WDM channels.

62. (New) The method of receiving an incoming optical signal of claim 61 wherein the crosstalk is cross phase modulation imposed on the first WDM channel by a second WDM channel during passage through an optical fiber transmission system.

63. (New) The method of receiving an incoming optical signal of claim 61 wherein the crosstalk is caused by four wave mixing occurring when the plurality of WDM channels generates a four wave mixing product which at least partially overlaps the optical spectrum of the WDM channel that experiences the crosstalk.